2/PART

09/530936

422 Rec'd PCT/PTO 05 MAY 2000

METHOD AND DEVICE FOR MONITORING AND/OR DETERMINING MOTOR OIL QUALITY

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The invention relates to a method and device for ~~of~~ monitoring and/or determining motor oil quality by determining the viscosity of the motor oil being used by internal combustion engines. ~~Furthermore, the invention concerns a device for carrying out the method.~~

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~~A plurality of~~ Many known devices such as machine tools and motor vehicles must be serviced in certain intervals in order to ensure their reliability and extend their service life. The motor oil used by the engine of a motor vehicle is subject to degradation and must be changed after reaching a certain degree of degradation, to avoid ~~since otherwise the~~ engine ~~might be damaged~~ damage due to insufficient lubrication and cooling. The service life of a motor oil depends, however, on many operating parameters, such as environmental conditions and the driver's driving style. Since these are not predictable, certain safety margins are used and the manufacturer specifies fixed service intervals and oil change intervals for the sake of simplicity, expressed, for example, as fixed mileage figures, and which must be observed for the manufacturer's warranty to remain valid. This results in the vehicle owner often having the vehicle serviced or the oil changed without any valid technical reason, which represents a considerable additional cost factor. Therefore, considerable efforts have been made for some time to match the oil change intervals to the actual degradation of the motor oil.

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a3 ~~With the method according to the definition of the species,~~ the degree of motor oil degradation or contamination ~~can be determined directly~~ include, for example, measuring ~~as a function of~~ the electrical resistance of the oil, the pressure differential between upstream and downstream sides of the oil filter, transparency, or chemical composition of the motor oil. The disadvantage of these direct methods is the additional cost of measuring, for example, the need for additional and special sensors, etc. Therefore, in addition to direct measuring methods, there are methods in which the degree of degradation of the motor oil is determined from operating parameters of the engine or the vehicle that are known otherwise.

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European Patent 174 601 discloses a warning system that measures and displays the degradation or aging of the oil in an internal combustion engine and emits a warning signal. The condition of the oil is evaluated and the result of the evaluation is output based on engine parameters such as rotation speed, instantaneous engine load, and oil temperature.

German Patent 41 31 969 presents a lubricating oil monitoring system, in which the oil parameters such as pressure, temperature, and viscosity are measured using a special sensor chip and the actual condition of the motor oil is derived from these parameters. The viscosity of the motor oil is determined using capacitive measurement of the dielectric constant of the oil at two different frequencies. As an alternative, the viscosity of the motor oil can also be determined by measuring sound wave dampening in the motor oil.

German Patent 32 28 195 discloses a method and a device for monitoring the time for a lubricating oil change in a vehicle engine. One essential step of this method is the determination of the contaminant level in the motor oil, which can be derived from the operating conditions of the engine, the level of contaminants being in direct relationship to the viscosity of the motor oil.

The disadvantage of the known methods is that either additional sensors are needed or the conclusion regarding the degree of degradation of the motor oil from known operating parameters does not have the required accuracy and therefore, for safety reasons, the motor oil is changed too early, resulting in extra cost to the owner of the vehicle.

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~~The~~ An object of the present invention is therefore to develop a method ~~allowing~~ the motor oil quality of a motor vehicle engine to be monitored and/or determined in a simple and accurate manner. ~~Furthermore, the object is to provide a device for carrying out the method.~~

~~This object is achieved through the features of Claims 1, 7, and 15. Preferred embodiments of the invention are the objects of the subclaims.~~

This object is achieved by determining and evaluating changes in oil viscosity as a function of temperature and engine frictional torque. The method according to the present invention allows changes in motor oil viscosity, which in turn are used for monitoring the motor oil quality, to be determined in a reliable manner. If the motor oil quality is known, an oil change is not required until the motor oil has actually degraded.

In a preferred embodiment of the method the engine frictional torque is derived from the starting torque. This allows the engine frictional torque to be determined in a simple manner.

In another advantageous embodiment of the present invention, the starting torque is determined from the electric power consumed by the starter during start, with the starter characteristics being known. This method is particularly simple, since current consumption essentially corresponds to the battery load and is therefore easy to determine. Current consumption as a function of motor oil quality is therefore simple to use for determining or evaluating quality.

Advantageously, changes in viscosity are not taken into account unless the value (actual value) is outside a range of -15% to +50% of a predefined viscosity value at the same temperature. This prevents slight variations in viscosity due to different marginal parameters resulting in an "oil change needed" display. It is ensured that only significant changes are taken into account in monitoring and subsequent action is not taken before the right time.

The object of the present invention is furthermore achieved ~~according to Claim 7 using a method of~~ by determining motor oil viscosity, in an internal combustion engine~~, in particular, according to Claim 1~~. By determining the viscosity of the motor oil from the engine frictional torque, with the latter being determined from data present in an engine

controller, the Proper time for oil change is determined in a simple manner.

In the case of a gasoline engine, the following engine data ~~are~~ may be advantageously used for determining the engine frictional torque: i) injection time and/or throttle valve position to determine the engine torque produced; ii) a clutch switch signal, showing whether torque is being transmitted to the drive train; iii) the load signal of the generator to determine the generator drive torque; iv) and signals concerning the operating state of any other auxiliary devices directly driven by the engine. Thus, reliable determination of the motor oil quality is Provided ~~ensured~~.

In a diesel engine, the following engine data ~~are~~ may be used for determining the frictional torque: i) a clutch switch signal, which shows whether torque is being transmitted to the drive train; ii) the generator load signal as a measure of the electric power generated by the generator; iii) the engine rpm; the injected amount of fuel; the engine temperature; and iv) the ambient temperature. This allows the engine oil quality to be reliably determined.

The object of the present invention can also be realized ~~is furthermore achieved~~ using a method of determining the motor oil viscosity in an internal combustion engine. By measuring the time from start at the engine to the moment when the starter disengagement speed is reached, so that if the constant fuel amount injected during this time is known, the engine frictional torque can be derived ~~estimated~~ from the measured time, and the motor oil quality can be reliably and accurately estimated therefrom ~~determined~~.

The object of the present invention can also be realized ~~is furthermore achieved~~ using a device for carrying out the method. In order to determine viscosity, this device has a control unit for processing and transforming data and at least one memory, with the characteristic curves, needed for determining the viscosity being stored in the memory or in each memory. Such a device allows the motor oil quality to be determined in a simple manner, since no additional measuring means are needed.

~~Further embodiments of the invention are presented in the subclaims and the~~

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~~description.~~ Preferred embodiments are explained in detail below with reference to the drawings.

Figure 1 shows a diagram for determining the oil viscosity in a diesel engine; and

Figure 2 shows a diagram for determining the viscosity from the electric power consumption of a starter.

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The calculation method illustrated in Figure 1 is based on the torque equilibrium of the engine that is not in gear and is idling. In this mode of operation, most quantities are constant, so that their effect on the engine torque generated can be stored in characteristic maps, preferably in the form of lookup tables.

The stationary torque equilibrium of an engine can be written as

$$M_{engine} = M_{clutch} + M_{aux.devices} + M_{friction} + M_{compression} \tag{1}$$

$$\text{where } M_{aux.devices} = M_{water\ pump} + M_{oil\ pump} + M_{generator} \tag{2}$$

if no other auxiliary devices are connected.

Under idling conditions, i.e., not in gear, the following equations apply:

$$M_{clutch} = 0 \text{ (any load is disengaged)} \tag{3}$$

$$N_{engine} = \text{constant} \Rightarrow dN/dt = 0 \text{ (idling speed is controlled)} \tag{4}$$

$$M_{water\ pump} = \text{constant} \tag{5}$$

$$M_{generator} = f(P_{electric}) \tag{6}$$

(generator torque is a function of electric power)

$$M_{compression} = f(T_{engine}, T_{ambient}) \quad (7)$$

(engine compression torque is a function of engine temperature and ambient temperature)

$$M_{friction} + M_{oil\ pump} = f(v_{oil}, T_{engine}, T_{ambient}), \text{ and} \quad (8)$$

$$M_{engine\ idling} = f(v_{oil}, T_{engine}, T_{ambient}) + M_{generator} = f(m_E) \quad (9)$$

(engine torque when idling is a function of the amount of fuel injected).

Therefrom the viscosity is determined assuming the validity of the above equations (3) to (9) during idling:

$$v_{oil} = f(M_{engine\ idling} - M_{generator}, T_{engine}) \quad (10)$$

At a reference temperature T_0 of the oil, which may be 40°C or 100°C, for example, we obtain:

$$v_{oil\ T0} = f(v_{oil}, T_{oil}/T_0) \quad (11)$$

The following definitions apply:

M = torque; N = rpm; T = temperature; P = power,
m_E = injected amount; v = viscosity.

The indices used are self-explanatory.

Figure 1 shows the diagram for this calculation using the example of a diesel engine. Generator signal 1, which is a measure of the electric power $P_{electric}$ generated by the generator, the injected amount m_E 2, engine temperature T_{engine} 3, ambient temperature $T_{ambient}$ 4, and oil temperature T_{oil} 5, as well as clutch signal 6, which shows whether or not the clutch is engaged, and engine rpm N 7 are available. Generator signal 1 is

recalculated into the respective generator torque 10 via a first characteristic map stored in first characteristic map unit 8. In the same manner, injected amount 2 is recalculated into the engine idling torque $M_{engine\ idling}$ 11 via a second characteristic map stored in a second characteristic map unit 9. Forming the difference between the two torques 10 and 11 thus obtained in subtractor 12, the desired frictional torque of equation (9) is obtained, which is a function of oil viscosity. Oil viscosity 14 at the reference temperature is calculated according to equations (10) and (11) via a third characteristic map stored in a third characteristic map unit 13, taking into account engine temperature 3, ambient temperature 4, and oil temperature 5. Characteristic curves or characteristic maps stored in characteristic curve units 8, 9, and 13 are engine-specific and are determined empirically. Since the engine rpm is kept constant by the idling controller, it does not have to be taken into consideration in the non-linear characteristic curve functions in characteristic map units 8, 9, 13. The time derivative of engine rpm 7 is calculated in differentiator 15. The engine rpm differential is ANDed with clutch signal 6 in AND gate 16 to form operating point signal 17. In another logic gate or operating point gate 18, operating point signal 17 of AND gate 16 determines whether or not the determined normalized oil viscosity 14 is valid, ~~ie.~~ i.e., whether the boundary conditions (3) and (4) of equations (10) and (11) are met.

The method illustrated in Figure 2 for determining oil viscosity is based on the evaluation of the energy equilibrium of the start sequence. Since all loads are basically turned off here and the generator delivers almost no electric power in this rpm range, the generator torque can be assumed, in a first approximation, to be the same for each start, as can the load torques caused by the other auxiliary devices (with the exception of the oil pump), assuming the same ambient conditions. The engine frictional torque and the compression energy can also be assumed to be functions of the engine temperature and time. Since the engine frictional torque and, in particular, the drive torque of the oil pump furthermore depends basically on the motor oil viscosity, the latter can be determined from the differences between the starter power and the known reference conditions during a start sequence.

Figure 2 shows a starter 20, which is powered via leads 21 and 22 during start. The respective current and voltage are determined by appropriate instruments A and V. A computing unit 23 calculates the starter power according to

$$P_{starter} = \eta_{starter} * I * U \qquad (12)$$

The starter torque generated by starter 20 is applied to an engine 24. The acceleration power of engine 24 is determined by another computing unit 26 from the engine rpm 25 generated according to

$$P_{accel.} = N * \Theta * dN/dt \qquad (13)$$

Difference ΔP between starter power and acceleration power, determined in subtractor 27, is the desired friction power of the engine, which corresponds to a frictional torque. Oil viscosity 30 is determined from the frictional torque in a characteristic map unit 28, taking into account engine temperature 29 using the equation

$$v_{oil} = f(\Delta P, T_{engine}). \qquad (14)$$

The notations used are defined as follows:

P = power; η = efficiency; I = current; U = voltage;
N = rpm; Θ = moment of inertia; ΔP = friction power.

In a third embodiment (not illustrated), the time from start to the moment when the starter disengagement rpm is reached is measured during the start sequence. An engine ~~The engine~~ controller injects a fixed amount of fuel during start, until the starter disengagement rpm is reached. Then the controller switches over to regular idling control. The exact moment of switch-over depends on the torque equilibrium of the engine in the start phase. Since the variation in the torque generated results from the injected fuel amount and is known, the torque loss i.e., ~~loss torque, i.e.~~, the engine frictional torque, can be estimated from the time elapsed

until the starter disengagement speed is reached. The viscosity of the motor oil can thus be estimated from the additional load using reference tests. The "engine regular mode status bit" signal from the engine controller can be used for this measurement. This bit is "0" in the start phase and is set to "1" when the starter disengagement speed is reached. The starter disengagement speed is usually about 1200 rpm.

Reference symbol list

1	generator load signal
2	injected amount
3	engine temperature
4	ambient temperature
5	oil temperature
6	clutch signal
7	engine rpm
8	first characteristic curve unit
9	second characteristic curve unit
10	generator torque
11	engine idling torque
12	subtractor
13	third characteristic curve unit
14	oil viscosity
15	differentiator
16	AND gate
17	operating point signal
18	operating point gate
20	starter
21	lead
22	lead
23	computing unit
24	engine
25	engine rpm
26	computing unit
27	subtractor
28	characteristic curve unit
29	engine temperature
30	oil viscosity